REMARKS

1. Request for Continued Examination

The present Reply is the submission required with and is being filed with a Request to Continued Examination under 37 CFR §1.114

2. Claim Rejections - 35 U.S.C. § 103(a)

a. Claims 36-39, 41, 44-46, and 54 are finally rejected under 35 U.S.C. ¶103(a) as being unpatentable over "Kan" (Kan 5,343,440) in view of "Ireson" (Ireson 6,201,765) and "Stewart" (Stewart , ASEG/SEG Conference - Adalaide, 1988).

b. Claims 40 and 42-43 are finally rejected under 35 U.S.C. 103(a) as being unpatentable over Kan in view of Ireson and as applied to claims 36-39 and 41 above, and further in view of Eaton (6382332).

c. Claims 47-48 are finally rejected under 35 U.S.C. 103(a) as being unpatentable over Kan in view of Ireson and Stewart as applied to claims 44-46 above, and further in view of Leaney.

d. Claims 49-51 are finally rejected under 35 U.S.C. 03(a) as being unpatentable over Kan in view of Stewart.

e. Claims 52-53 are finally rejected under 35 U.S.C. 103(a) as being unpatentable over Kan in view of Stewart.

Claims 44-54 have been canceled, thus mooting the rejections cited in paragraphs c, d and e.

Claim 36 is the only remaining independent claim in the application. With reference to the rejection of claim 36 cited above as obvious over Kan, Ireson and Stewart, the Applicant respectfully request reconsideration for the following reasons. The Applicant believes, as explained below, that claim 36 is not claimed, mentioned, or implied in Kan in view of Ireson

and Stewart, whether each of these documents is considered alone or in combination. In the following analysis, the Applicant will respond individually to each reason given for the rejection of claim 36.

1. From Examiner's comments on page 5:

"With regard to claim 36, Kan discloses a method of estimating velocity ahead of a drill bit disposed in a subsurface region (Column 8, Line 40 to Column 9, Line 10). Kan discloses obtaining surface seismic data for a region of interest (Column 6, Lines 20-37; Column 8, Lines 40-57). Kan discloses during drilling of a borehole traversing the subsurface region, determining a travel time of a seismic wave generated from a surface of the region to a location in the borehole when the drill bit is at selected depths in the borehole (Column 7, Line 66 to Column 8, Line 57). Kan discloses determining a velocity from the travel time and the selected depths (Column 8, Lines 1-57)."

The Applicant does not dispute that Kan discloses the first three elements the four elements of claim 36 to someone skilled in the art. However, the critical fourth element, namely, *"**inverting the surface seismic data obtained using the plurality of surface-located seismic sources and receivers to determine a velocity ahead of the drill bit while constraining velocity between the surface and the drill bit to be consistent with the velocity determined from the travel time**"* is not mentioned or implied an any part of Kan.

2. From Examiner's comments on pages 5-6:

"Kan discloses inverting reflection seismic data (data reflected from structures below drillbit and received in the borehole receivers), although not specifically the surface seismic data, to determine a velocity ahead of the drill bit while constraining the velocity between the surface and the drill bit to be consistent with the velocity determined from the travel time (Column 6, Lines 20-37; Column 8, Line 40 to Column 9, line 3)."

The fourth element of claim 36, differs significantly from what the Examiner has stated in two respects:

A. Kan's inversion does not include **constraints** determined from measured seismic travel time between the Earth; surface and various known depths in the subsurface, wheras claim 36 describes a constrained inversion where the in-situ velocity measurements from surface to the bit location are used to constrain the inversion of velocities below the bit. This is the primary innovation in this application and it is not mentioned anywhere in the Kan patent.

B. Kan describes inversion of vertical seismic profile (VSP) data, that is, seismic data obtained from measurements made within a wellbore. Claim 36, by contrast, clearly recites inversion of surface seismic data. These two are very different things requiring different techniques and different *a priori* information.

   In VSP inversion reflections only traverse the subsurface between the reflector and the position of one or more downhole receivers (in the present example, at the drill bit location). Therefore, the velocities between the surface and the drill bit are irrelevant; they are not part of the inversion. This is one reason why Kan does not mention constrained inversion because it is not applicable to the VSP inversion disclosed in Kan. Please see Figure 1 below for more explanation of this critical point.

The Applicant's specification states the above constrained inversion techniques in paragraphs [0035], [0036] and [0037], and that claim 36 and its dependent claims are filly enabled by the specification as originally filed.

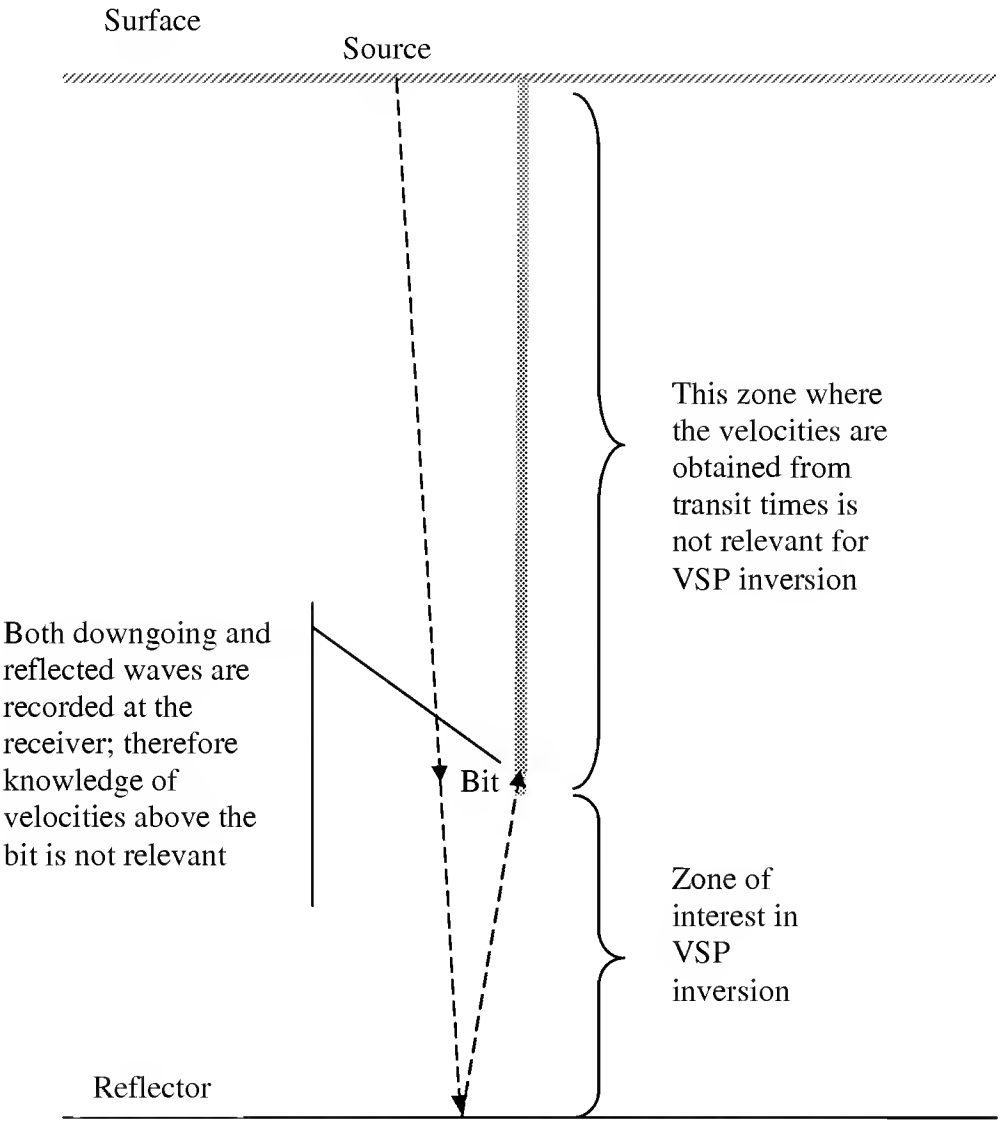

Figure 1. Zone for VSP inversion. Because the receiver is only located downhole (e.g., at the bit location) both downgoing (incident) and upgoing (reflected) waves are recorded and the knowledge of acoustic reflective properties of the subsurface between the surface and the bit is not required in VSP inversion. In contrast, in surface seismic data receivers are all located at or near the surface and the knowledge of velocities between the surface and the bit (obtained from

transit times) is of paramount importance while inverting the velocities below the bit. This is the reason why the "constrained" inversion of claim 1 is very important for surface seismic, while it is not applicable to VSP inversion and therefore not discussed by Kan. Thus, a person skilled in the art would not look to Kan as a technique for constraint of seismic velocities in a surface seismic inversion procedure.

3. From Examiner's comments on page 6:

"Kan discloses that the VSP data is used to replace interval transit times from the surface seismic data with the velocity determined from the VSP checkshot survey to the depths of the borehole that the VSP data was taken. Replacing the velocity constrains it to being the velocity determined from the transit times of the VSP survey in the borehole."

It is very clear that the VSP transit time measurements in the already drilled part of the borehole (above the bit depth) are only used to replace the seismic-computed velocities in the zone. They have absolutely no effect on the velocities below the bit depth – except for shifting them in depth position. This is not "constrained inversion". In fact Kan never uses the word "constrain" in this context (it appears only three times in the completely different context of the Simplex algorithm).

As described in Figure 1 abouve, "replacing" velocities from transit times down to the bit depth cannot be considered as "constraint" because they are not relevant for the VSP inversion Kan discusses.

4. From Examiner's comments on page 6:

"Kan discloses surface seismic data and discloses a plurality of surface located source and receiver locations used to take the surface seismic data as common midpoint data (Column 6) (Fig. 7a), but does not specifically disclose that a plurality of surface located sources and a

plurality of surface located receivers are used to obtain the surface seismic data. Ireson teaches that it is known that surface seismic data are obtained using a plurality of surface sources and a plurality of surface receivers are used in obtaining surface seismic data (Fig. 1) (Column 1, Lines 9-40). It would have been obvious to use a plurality of sources and receivers to obtain the surface seismic data in Kan as taught by Ireson in order to obtain common midpoint data about an origin or midpoint."

The Applicant does not dispute the foregoing; however the above description does not mention constraining the inversion of surface seismic ahead of the drill bit using the surface to bit measured travel times,

5. From Examiner's comments on page 6:

"Although Kan does not teach inverting the surface seismic data, Kan does disclose finding the velocities above the drill bit with the VSP, and then using this data in the process of finding interval velocities ahead of the bit by inversion methods for seismic data that has been reflected from structures ahead of the bit and received at receivers in the wellbore (Column 6, Lines 20-37; Column 8, Line 40 to Column 9, line 3). "

Kan does not discuss "constrained surface seismic inversion" anywhere. Column 6, Lines 20-37 describe conventional velocity estimation from surface seismic data. There is no mention of borehole measurements or constrained inversion. The only inversion discussed in Kan is the VSP inversion for which the constraints are not mentioned, and in fact cannot be used as a proxy for constrained inversion of surface obtained seismic data.

6. From Examiner's comments on pages 6 and 7:

"Kan teaches that the velocity determined from the surface seismic data is constrained by the velocity determined from the travel times and depths of the waves from the surface to the

borehole location (Column 6, Lines 20-37; Column 8, Line 40 to Column 9, line 3), but does not specifically disclose that the velocity determined from the surface seismic data is determined by an inversion of the surface seismic data."

The Applicant respectfully disagrees that such conclusion can be drawn from the cited portions of Kan. In Column 8, Line 40 to Column 9, line3 Kan teaches:

(a) Replacing velocities in already drilled zone with VSP velocities; and
(b) Inversion of VSP data (not surface seismic), without any constraints below the drilled zone, completely independent form the surface seismic data. Again "constrained inversion" of any kind is not mentioned or implied anywhere.

It is very clear from Kan's discussion that "Replacing velocities in already drilled zone with VSP velocities" has only the effect of "depth shifting" of any velocities ahead of the bit. This can easily be understood by those skilled in the art that mere depth shifting has no relationship to constrained inversion.

7. From Examiner's comments on page 7:

"Stewart teaches that inversion methods are used on both VSP and surface seismic data when determined velocity structures of underground formations (Page 358, Summary; Page 359, Second Column to Page 360 Second Column). It would have been obvious to use an inversion process on the surface seismic data in Kan to determine the velocity structure as taught by Stewart in order to determine the velocity structure of the subsurface in depth."

The Applicant must respectfully disagree with the conclusion above. AS previously explained with respect to Kan, only VSP data are used, and to the text they are used, they are used only for the purpose of depth shifting seismic events based one measured VSO travel times. Stewart only describes building a velocity model using well data including VSP, and using this velocity model

to migrate (image) the surface seismic data. There is no inversion of surface acquired seismic, particular at greater than bit depths constrained by VSP information described in Stewart.

Accordingly Applicants believe that the entire combination of claim 36 is not disclosed expressly or impliedly in the combined documents Kan, Ireson and Steward, and respectfully request that the Examiner withdraw the §103 rejection of independent claims 36.

Dependent claims 37 – 43 ultimately depend from claim 36 and are believed to be patentable for at least the reasons stated above with reference to claim 36.

All matters set forth in the Office Action having been addressed, it is believed that all claims are in condition for allowance. Favorable consideration and an early indication of allowability are respectfully requested.

Applicants further note that no fee is believed required for consideration of this Amendment (other than the RCE fee). However, if any additional fee is necessary or if there is overpayment, Applicants hereby authorize payment of such fee from or refund of such excess to Deposit Account No. 19-0610 (19.0380).

Respectfully submitted,

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